Designation: E2885 – 21

# Standard Specification for Handheld Point Chemical Vapor Detectors (HPCVD) for Homeland Security Applications[1]

This standard is issued under the fixed designation E2885; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

## 1. Scope

1.1 *General:*

1.1.1 This document presents baseline performance requirements and additional optional capabilities for handheld point chemical vapor detectors (HPCVD) for homeland security applications. This document is one of several that describe chemical vapor detectors (for example, handheld and stationary) and chemical detection capabilities including: chemical vapor hazard detection, identification, and quantification. An HPCVD is capable of detecting and alarming when exposed to chemical vapors that pose a risk as defined by the Acute Exposure Guideline Levels for Selected Airborne Chemicals (AEGL).

1.1.2 This document provides the HPCVD baseline requirements, including performance, system, environmental, and documentation requirements. This document provides HPCVD designers, manufacturers, integrators, procurement personnel, end users/practitioners, and responsible authorities a common set of parameters to match capabilities and user needs.

1.1.3 This document is not meant to provide for all uses. Manufacturers, purchasers, and end users will need to determine specific requirements including, but not limited to, use by HAZMAT teams, use in explosive atmospheres, use with personal protective equipment (PPE), use by firefighters and law enforcement officers, special electromagnetic compatibility needs, extended storage periods, and extended mission time. These specific requirements may or may not be generally applicable to all HPCVDs.

1.2 *Operational Concepts*—HPCVDs are used to detect, identify, classify, or quantify, or combinations thereof, chemical vapor hazards that pose 30-min Acute Exposure Guideline Level-2 (AEGL-2) dangers. The HPCVD should not alarm to environmental background chemical vapors and should provide low false positive alarm rates and no false negatives. Uses of an HPCVD include search and rescue, survey, surveillance, sampling, and temporary fixed-site monitoring. An HPCVD should withstand the rigors associated with uses including, but not limited to, high- and low-temperature use and storage conditions; shock and vibration; radio frequency interference; and rapid changes in operating temperature, pressure, and humidity.

1.3 *HPCVD Chemical Detection Capabilities*—Manufacturers document and verify, through testing, the chemical detection capabilities of the HPCVD. Test methods for assessing chemical detection capabilities are available from the Department of Homeland Security and the Department of Defense and are listed in Appendix X3.

1.4 *HPCVD System and Environmental Properties*—Manufacturers document and verify, through testing, the system and environmental properties of the HPCVD. Example test methods for assessing the system and environmental properties are listed in Appendix X4.

1.5 *Units*—The values stated in SI units are to be regarded as the standard. Vapor concentrations of the hazardous materials are presented in parts per million (ppm) as used in *Acute Exposure Guideline Levels for Selected Airborne Chemicals*, Vols 1-9 (see 2.1) and in $mg/m^3$.

1.6 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.7 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

[1] This specification is under the jurisdiction of ASTM Committee E54 on Homeland Security Applications and is the direct responsibility of Subcommittee E54.01 on CBRNE Detection and Decontamination.

Current edition approved Sept. 1, 2021. Published September 2021. Originally approved in 2013. Last previous edition approved in 2013 as E2885 – 13. DOI: 10.1520/E2885-21.

## 2. Referenced Documents

2.1 *Acute Exposure Guideline Levels:*[2]

Acute Exposure Guideline Levels for Selected Airborne Chemicals, Vols 1-9

2.2 *Code of Federal Regulations:*[3]

CFR Title 40 Protection of the Environment, Part 72.2 Permits Regulation, Definitions

CFR Title 10 Gas and Aerosol Detectors Containing Byproduct Material, Part 30.20, Energy

## 3. Terminology

3.1 *Definitions:*

3.1.1 *30-minute Acute Exposure Guideline Levels for Selected Airborne Chemicals (30-min AEGL value), n*—represent exposure limits for the general public and are applicable to emergency exposure periods for 30 minutes.

3.1.2 *AEGL-1, n*—airborne concentration (expressed as ppm or mg/m$^3$) of a substance above which it is predicted that the general population, including susceptible individuals, could experience transient health effects.

3.1.3 *AEGL-2, n*—airborne concentration (expressed as ppm or mg/m$^3$) of a substance above which it is predicted that the general population, including susceptible individuals, could experience irreversible or other serious, long-lasting adverse health effects or an impaired ability to escape.

3.1.4 *AEGL-3, n*—airborne concentration (expressed as ppm or mg/m$^3$) of a substance above which it is predicted that the general population, including susceptible individuals, could experience life-threatening health effects or death.

3.1.5 *alarm, n*—sound, light, vibration, and/or data communication signal to the operator(s) indicating that the handheld point chemical vapor detector (HPCVD) has detected the presence of a chemical vapor of interest at or above the alarm threshold value.

3.1.6 *alarm threshold value, n*—vapor concentration corresponding to an AEGL value (AEGL-1, AEGL-2, or AEGL-3) that activates an HPCVD alarm.

3.1.7 *background chemical vapors, n*—incidental chemical vapors present in the environment at vapor concentrations lower than the 30-minute AEGL-1 values.

3.1.8 *consumables, n*—HPCVD components that require periodic replacement.

3.1.9 *false negative, n*—the HPCVD fails to alarm in the presence of a chemical of interest when the vapor concentration is at or above the indicated alarm threshold value.

3.1.10 *false positive alarm, n*—the HPCVD indicates the presence of a chemical of interest when none is present or if the chemical is present at vapor concentrations less than 50 % of the indicated alarm threshold value.

3.1.11 *indicator, n*—information other than an alarm provided to the operator by the HPCVD.

3.1.12 *laboratory challenge stream, n*—a synthesized chemical vapor mixture used to verify in the laboratory the chemical detection capabilities of an HPCVD.

3.1.13 *mean time between failures, n*—estimate of the elapsed time between inherent failures of a system during operation, one measure of system reliability.

3.1.14 *probability of detection, n*—under specific conditions, the probability that the HPCVD will activate an alarm when a chemical of interest is present at or above the alarm threshold values.

3.1.15 *response time, n*—time for the HPCVD to detect and activate an alarm when exposed to a chemical of interest at vapor concentrations at or above the alarm threshold value.

3.1.16 *saturation, n*—a condition in which the detector response no longer increases with increased vapor concentration.

3.1.17 *selectivity, n*—ability of an HPCVD to distinguish one or more chemicals of interest in the presence of background chemical vapors.

3.1.18 *sensitivity, n*—ability to detect one or more chemicals of interest at the alarm threshold values within the specified response time.

3.1.19 *vapor, n*—in the context of this document, vapor refers to either gases or gas phase chemicals where the same substance also exists in either a liquid or solid state.

## 4. Chemical Detection Performance Requirements

4.1 The manufacturer shall document the capabilities of the HPCVD to detect, identify, and quantify chemical vapor hazards.

4.2 *Detection and Hazard Identification:*

4.2.1 The baseline capability of the HPCVD is to detect and alarm to at least four hazardous chemical vapors listed in the Acute Exposure Guideline Levels for Selected Airborne Chemicals. The tables in Appendix X1 provide a representative list of chemical vapor hazards.

4.2.2 The HPCVD shall detect the manufacturer-documented chemical vapors without user intervention.

4.2.3 The HPCVD:

4.2.3.1 Shall alarm in the presence of manufacturer-documented chemical vapors at the vapor concentrations given in 4.3 with response times given in 4.4;

4.2.3.2 Shall indicate each 30-min AEGL value that the detected chemical vapor(s) is at or above; and

4.2.3.3 Should indicate the chemical class or specific chemical(s) that is detected.

4.3 *Sensitivity:*

4.3.1 For each manufacturer-documented chemical vapor, the manufacturer:

4.3.1.1 Shall declare and document the HPCVD capability to alarm at the 30-min AEGL-2 value;

4.3.1.2 May declare and document the HPCVD capability to alarm at the 30-min AEGL-1 value; and

[2] Committee on Acute Exposure Guideline Levels, Committee on Toxicology, Board on Environmental Studies and Toxicology, Division on Earth and Life Studies, National Research Council of the National Academies; 2000-2010, http://www.epa.gov/oppt/aegl/index.htm, updated August 2010.

[3] Available from U.S. Government Printing Office Superintendent of Documents, 732 N. Capitol St., NW, Mail Stop: SDE, Washington, DC 20401, http://www.access.gpo.gov.

4.3.1.3 May declare and document the HPCVD capability to alarm at the 30-min AEGL-3 value.

4.3.2 The HPCVD alarm signal shall automatically cease within 2 min after the concentration drops below half of the alarm threshold values.

4.3.3 At vapor concentrations greater than the 30-min AEGL-3 values:

4.3.3.1 The HPCVD shall continue to alarm;

4.3.3.2 If the detector is saturated, the HPCVD shall indicate it is saturated; and

4.3.3.3 The HPCVD should be designed to avoid detector saturation at vapor concentrations below twice the AEGL-3 vapor concentration values.

4.3.4 The HPCVD should indicate relative concentrations, for example, low, medium, and high levels based on 30-min AEGL-2 vapor concentrations.

4.3.5 The HPCVD may optionally indicate the vapor concentration of the chemical(s) present in absolute quantities (for example, ppm or mg/m$^3$).

4.4 *Response Time*—The HPCVD shall detect and alarm within times indicated in Table 1 for 30-min AEGL-2 values and may optionally detect and alarm within the times for 30-min AEGL-1 values and 30-min AEGL-3 values.

4.5 *Chemical Detection Climate*—For each of the manufacturer-documented chemical detection capabilities:

4.5.1 The HPCVD shall perform within the temperate climate range listed in Table 2;

4.5.2 The HPCVD may perform within the low- or high-temperature climate ranges or both listed in Table 2;

4.5.3 The chemical detection capabilities within each climate range shall be demonstrated by tests at the temperatures and relative humidities (non-condensing) listed in Table 3;

4.5.4 The HPCVD shall perform in atmospheric pressures from 101 kPa (sea level) to 68 kPa; and

4.5.5 The manufacturer may extend the range of operation.

4.6 *Probability of Detection*—For each of the manufacturer-documented chemical vapors, an HPCVD shall achieve a probability of detection of at least 85 % under any condition within each of the manufacturer-documented climate range(s) as specified by an 80 % lower confidence bound (see Appendix X2). The probability of detection shall be verified by:

4.6.1 Testing a single HPCVD, representative of all the HPCVDs with the same model designation, which shall detect and alarm:

4.6.1.1 For nine of nine replicate tests, or

4.6.1.2 For 17 of 18 replicate tests.

4.6.2 The replicate tests shall be performed:

4.6.2.1 Using laboratory challenge streams that shall consist of the chemical of interest diluted in zero air (see CFR Title 40, Part 72.2).

**TABLE 1 HPCVD Response Time**

| 30-min AEGL Values | Maximum Response Time | Requirement |
|---|---|---|
| AEGL-2 | 120 s | Required |
| AEGL-1 | 15 min | Optional |
| AEGL-3 | 30 s | Optional |

**TABLE 2 HPCVD Chemical Detection Climate Ranges**

| Climate Ranges | Temperature (°C) | % Relative Humidity | Water Vapor Content (g/m$^3$) |
|---|---|---|---|
| Low temperature | -10 to 5 | 5 to 100 | 0.1 to 6.8 |
| Temperate | 5 to 35 | 5 to 100 | 0.3 to 32 |
| High temperature | 35 to 50 | 5 to 77 | 2.0 to 32 |

**TABLE 3 HPCVD Testing Conditions**

| Manufacturer Documented Climate Ranges | Temperature (°C) | % Relative Humidity | Water Vapor Content (g/m$^3$) |
|---|---|---|---|
| Temperate | 7 ± 2 | 77 ± 25 | 6 ± 2 |
| | 33 ± 2 | 17 ± 6 | 6 ± 2 |
| | 33 ± 2 | 78 ± 6 | 29 ± 2 |
| Low Temperature | -5 ± 2 | | 0 |
| High Temperature | 45 ± 2 | 43 ± 3 | 29 ± 2 |

4.6.2.2 With the laboratory challenge streams at the temperatures and relative humidities listed in Table 3.

4.6.3 The vapor concentration of the chemical of interest shall:

4.6.3.1 Be measured by an independent method, and

4.6.3.2 Have a measured value at the documented AEGL value plus the expanded uncertainty of the measured vapor concentration at the 95 % confidence level. Therefore, the vapor concentration of the laboratory challenge stream shall be set above the AEGL value by an amount equal to the expanded measurement uncertainty.

4.7 *False Positive Alarm Characterization:*

4.7.1 The HPCVD shall not alarm when exposed for 5 min to:

4.7.1.1 Each of the following four background chemical vapors representing:

*(1)* Exhaust from low-sulfur diesel fuel,

*(2)* Gasoline exhaust,

*(3)* Tobacco smoke, and

*(4)* Aqueous film-forming foam.

4.7.1.2 Each laboratory challenge stream shall:

*(1)* Consist of one of the specific background chemical vapors of interest at 1 % of the saturation vapor pressure at 23 °C diluted in zero air;

*(2)* Be at a temperature between 20 °C and 25 °C and a relative humidity between 45 % and 55 %; and

*(3)* Not contain any chemical on the AEGL list at concentrations greater than the 30-min AEGL-1 vapor concentration value;

4.7.2 The manufacturer shall test the HPCVD under common ambient conditions to characterize the false positive alarm rate. This test should include three different ambient conditions with each test having a minimum duration of 150 h. The manufacturer shall document:

4.7.2.1 The test conditions including a description of the test location and potential background chemical vapors or sources of background chemical vapors or both that could cause a false positive alarm;

4.7.2.2 The number of hours operated in the environment;

4.7.2.3 The ranges of temperatures, pressures, and relative humidity values; and